EFFECT OF PARTICLE SIZE ON XYLOSE, GLUCOSE AND ARABINOSE PRODUCTION FROM OIL PALM TRUNK

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A thesis submitted in fulfillment
of the requirements for the award of the degree of
Bachelor of Chemical Engineering (Biotechnology)

Faculty of Chemical & Natural Resources Engineering
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FEBRUARY 2013

ABSTRACT

Oil palm trunks are one of the potential lignocellulosic sources for monosaccharides production. Acid hydrolysis and enzymatic hydrolysis method were combined to obtain higher yield of monosaccharides. Therefore, this paper was designed to study the effect of particle size of oil palm trunk (OPT) on the production of xylose, glucose and arabinose. In acid hydrolysis, 3.24% sulphuric acid (H_2SO_4) was used at temperature of 121°C for 40 minutes to degrade the hemicelluloses thus generates xylose. The filtrate was analysed using High Performance Liquid Chromatography (HPLC).The result showed that the highest xylose, glucose and arabinose generated were 14.092 g/L, 10.233 g/L and 4.761 g/L respectively at 160µm particle size. Solid wastes from acid hydrolysis were degraded by cellulotic enzyme to produce glucose and the hydrolysate was analysed using YSI Biochemistry Analyser. The highest glucose produced was 2.82 g/L at 800µm particle size. Overall, the highest glucose production was 12.873 g/L at 160µm particle size. As the conclusion, combination of both methods helps in increasing the glucose production and reduces the abundant waste of biomass. From this research, it is recommended that purification method should be done in order to obtain high purity of xylose, glucose and arabinose

ABSTRAK

Batang kelapa sawit adalah salah satu sumber lignoselulosik yang berpotensi untuk penghasilan monosakarida. Kaedah hidrolisis asid dan hidrolisis enzim telah digabungkan untuk memperolehi pengeluaran monosakarida yang lebih tinggi. Oleh itu, tujuan kajian ini dijalankan adalah untuk mengkaji kesan saiz zarah batang kelapa sawit (OPT) terhadap pengeluaran glukosa, xilosa, dan arabinosa. Hidrolisis asid melibatkan penggunaan 3.24% asid sulfurik (H_2SO_4) pada suhu 121°C selama 40 minit untuk merungkaikan ikatan hemiselulosa dan menghasilkan xilosa. Cecair turasan daripada hidirolisis asid dianalisa menggunakan sistem kromatografi (HPLC). Keputusan kajian menunjukkan bahawa penghasilan xilosa, glukosa dan arabinosa yang tertinggi adalah masing-masing sebanyak 14.092 g /L, 10.233 g /L dan 4.761 g /L pada saiz zarah 160µm. Sisa pepejal daripada hidrolisis asid diuraikan oleh enzim selulotik untuk menghasilkan glukosa. Hidrolisat daripada hidrolisis enzim dianalisa menggunakan YSI Biokimia Analisa. Penghasilan glukosa yang tertinggi dihasilkan adalah sebanyak 2.82 g / L pada saiz zarah 800µm. Secara keseluruhannya, penghasilan glukosa yang tertinggi adalah sebanyak 12.873 g/L pada saiz zarah 160µm. Sebagai kesimpulan, gabungan dua kaedah hidrolisis membantu dalam meningkatkan penghasilan glukosa dan mengurangkan lebihan sisa biojisim. Daripada kajian ini, adalah dicadangkan bahawa kaedah penulenan boleh dijalankan untuk mendapatkan ketulenan xilosa, glukosa dan arabinosa yang tinggi.

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LIST OF ABBREVIATIONS

FTIR	Fourier Transform Infrared Spectroscopy
GFP	Green Flouresent Protein
HPLC	High Liquid Performance Chromatography
L	Liquid
OPT	Oil Palm Trunks
PAA	Peracetic Acid
RMW	Red Meranti Wood
S	Solid
SEM	Scanning Electron Microscope

LIST OF SYMBOLS

g	Gram
kg	Kilogram
ml	Milliliter
µl	Microliter
H_2O	Water
ºC	Degree Celsius
cm^{-1}	Per Centimeter
g	Grams
g/L	Grams per liters
kg	Kilogram
M	Molarity (moles/ liters)
mm	Millimeter
µm	Micrometer
mol/dm^3	Moles/ decimeter Cubed
rpm	Rotation per minute
v/w	Volume per weight
w/w	Weight per weight
%	Percentage

APPENDIX A

PREPATION OF ACID SOLUTION

A) 2M Sulfuric Acid (H_2SO_4)

$$M = \frac{SG \times Purity \times 1000}{Mw}$$

Where,

M = molarity @ concentration of stock H2SO4

SG = specific gravity of H2SO4 = 1.84

Purity = percentage of stock H2SO4 = 96% = 0.96

MW = molecular weight H2SO4, g/mol = 98.08 g/mol

Molarity of H2SO4 needed from stock solution is as follow:

$$M = \frac{1.84 \times 0.96 \times 1000}{98.08}$$

= 18.01 M

Thus, using equation:

$M_1V_1 = M_2V_2$

(2M)(1000L) = (18.01M) V_2

V2 = 106.6 L = **106.6 mL stock H2SO4** is needed to be dilute with 1000 L distilled water to obtained 0.04M H2SO4.

APPENDIX B

STANDARD STOCK SOLUTION OF HPLC

1) Xylose standard stock solution (100 g/l) : 10 ml

1 g of xylose was diluted in 10 ml H_2O

Composition (g/l)	Stock solution (µL)	Water (µL)
1	10	990
2	20	980
4	40	960
8	80	920
16	160	840

2) Glucose standard stock solution (20 g/l) : 50 ml

2 g of Glucose was diluted in 100 ml H_2O

Composition (g/l)	Stock solution (µL)	Water (µL)
0.5	25	975
1	50	950
2	100	900
4	200	800
8	400	600

3) Arabinose standard stock solution (20 g/l) : 50 ml

0.2 g of Arabinose was diluted in 10 ml H_2O

Composition (g/l)	Stock solution (µL)	Water (µL)
0.1	10	1990
0.5	25	975
1	50	950
2	100	900
4	200	800

APPENDIX C

HIGH PERFORMANCE LIQUID CHROMATOGHRAPHY (HPLC) RESULTS

CHAPTER 1

INTRODUCTION

1.1 Background of Proposed Study

Oil palm trunks (OPT) are a possible lignocellulosic source (Young *et. al.*, 2011). According to Jung *et. al.*, (2011), approximately 4.49 million hectares in Malaysia are used oil for palm agriculture and around 15.2 million tonnes of OPT are generated yearly. The residue of oil palm trunk in Malaysia makes it as the most abundant biomass resources. In order to reduce the numbers, the residues are burned in the field which causes major air pollution (Najafpour *et. al.*, 2007). Hydrolysis of the lignocellulosic of OPT can produce xylose, glucose and arabinose (Lim *et. al.*, 1996; Chin *et. al.*, 2011). However most the research only studied on the hydrolysate product. The generated solid waste (cake) is not analysed for further study. Therefore, the abundant of biomass is still a problem to the environment. Thus, in order to maximise the production, through delignification, acid pre-treatment and enzymatic hydrolysis, the solid waste (cake) containing cellulose and lignin will be converted to glucose. This method helps reduce the waste, decrease the excessive of oil palm trunks (OPT) and save the environment.

1.2 Problem Statement

The chemical composition of the OPT is cellulose 41.2%, hemicelluloses 34.4%, lignin 17.1%, ash 3.4% and ethanol soluble 2.3% (Robert *et. al.*, 2008). Acid pre-treatment of oil palm trunk (OPT) recover cellulose. Then, cellulose will be converted to glucose. Because of this, lignin and hemicelluloses will be generated approximately 51.5% as the liquid waste. The waste eventually pollutes the environment.

Previous studies recover hemicellulose from the biomass through acid hydrolysis producing xylose, glucose and arabinose (Lim *e.t al.*, 1996; Chin *et. al.*, 2011). These studies generated 48.3% solid waste which consists of cellulose and lignin. Therefore, abundant of waste is still being generated either from acid-pretreatment or acid hydrolysis.

1.3 Research Objectives

- To study the effect of different particle size of oil palm trunk (OPT) on the production of xylose, glucose and arabinose.

- To determine the maximum yield of xylose, glucose and arabinose from the oil palm trunk (OPT).

1.4 Research Questions

- What is the effect of particle size to the production of xylose, glucose and arabinose?

- What is the maximum yield of glucose, xylose and arabinose from the oil palm trunk (OPT)?

1.5 Scope of Study

Pre-treatment of oil palm trunk (OPT) was crushed in a high speed rotary cutting mill and sundried for a day. The resulting sample was sieved to obtained different particle size. The particle size consists of 160, 200, 315, 630 and 800 µm sieves by using vibrator sieve shaker. Acid hydrolysis process was carried out in an autoclave at constant temperature 120^0C for 30 to 60 minutes. The acid used for the process was sulphuric acid. For delignification process, the NaOH was used to pre-break the line of the lignin and cellulose.

Acid pre-treatment was done before the enzymatic hydrolysis. It involves the removal of lignin content using peracetic acid (PAA). Then the enzymatic method was done. Commercial cellulolytic enzymes (cellulase and cellobiase) act as catalysts to convert cellulose to glucose. The anaylsis of production of xylose, glucose and arabinose from the liquid waste was done by High Performance Liquid Chromatoghraphy (HPLC) with the column used was RCM Monosaccharide.

Meanwhile analysis production of the glucose from the enzymatic hyrolysis was done by YIS Biochemistry Analyser.

1.6 Significance of Study

- Acid hydrolysis of hemicelluloses and cellulose hydrolysis by enzyme from oil palm trunk (OPT) was studied in this research in order to reduce liquid or solid waste generated from the process.

- Liquid waste filtered after acid hydrolysis was treated to produce xylose, glucose and arabinose from hemicelluloses (Lavarack *et. al.*, 2001; Najafpour *et. al.*, 2007).

- Solid waste filtered after acid hydrolysis was treated to produce glucose. Thus, this research will only generate 17.1 % lignin as the liquid waste. The minimum amount of waste can reduce the pollution and more environmental friendly.

CHAPTER 2

LITERATURE REVIEW

2.1 Monosaccharides

Monosaccharides are one type of sugars. They are small components that belong to the class of carbohydrates. Monosaccharides are the simplest carbohydrates and are categorized according to either aldehyde or ketone derivatives. Since they are the simplest carbohydrates, monosaccharides cannot be hydrolyzed to smaller carbohydrates. A monosaccharides has just one ring instead of disaccharides has two and polysaccharides has many rings. Figure 2.1 shows type of carbohydrates consists of monosaccharides, disaccharides and polysaccharides.

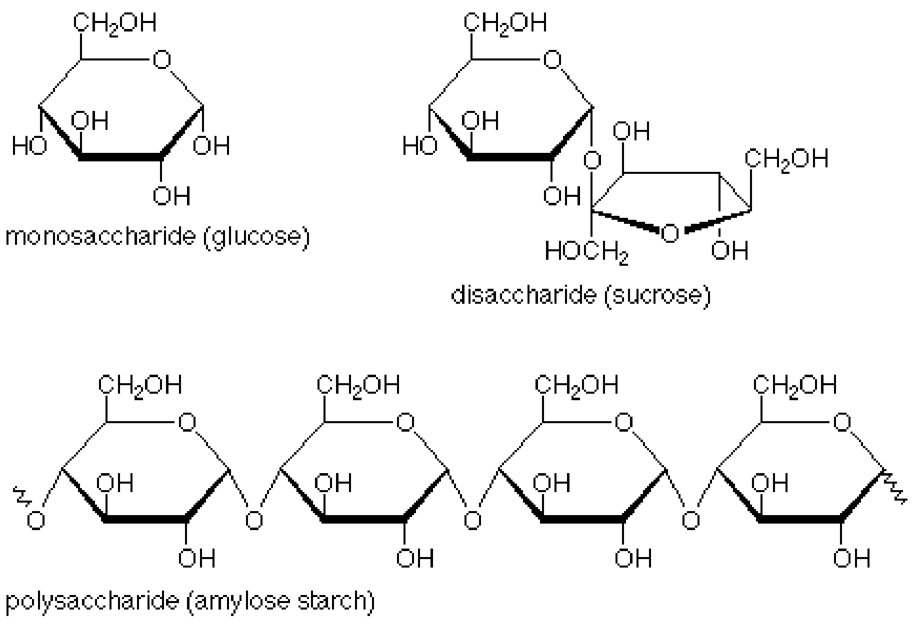

Figure 2.1 Type of carbohydrates

(Source : Sjoman, *et. al.*, 2008)

Monosaccharides can be differentiated based on their three different characteristicswhich are carbonyl group placement, the number of carbon atoms contained and its chiral handedness. Simple sugars that have aldehyde as the carbonyl group are called aldose. Meanwhile carbonyl group of ketone attached to the monosaccharides is named ketose.

2.1.1 Xylose

According to Sjoman *et. al.*, (2008), xylose is a pentose sugar and it has molecular structure as $C_5H_{10}O_5$. They normally hydrolyzed from xylan like wood, rice husk, corn stalk, wheat straw and flax straw. Pretreatment of complex structure of lignocellulosic biomass can produce xylose. It can be done either by chemical or biological hydrolysis method.

Xylose can be appears to be a major component of hemicellulose in biomass and agricultural waste residue (David *et. al.*, 2003). It can be used as a raw material (substrate) for production of many varieties of compounds by chemical and biological processes (Wymn, 1994). Usually, lignocellulosic biomass will be easily released xylose by hydrolysates of samples with acid catalysts (Martin *et. al.*, 2002). Figure 2.2 describe the structure of xylose.

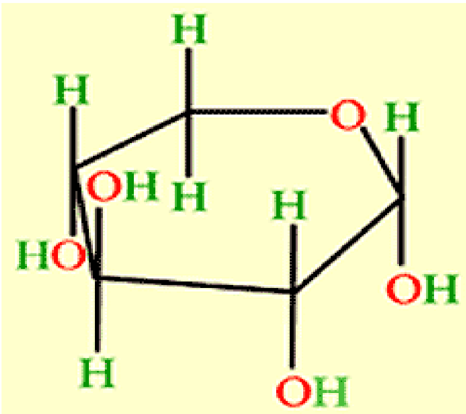

Figure 2.2 Structure of Xylose

(Source: David *et. al.*, 2003)

2.1.2 Glucose

Glucose is a simple monosaccharide sugar which is a very essential carbohydrate in biology. Glucose ($C_6H_{12}O$) contains six carbon atoms, one of which is part of an aldehyde group Thus, glucose is an aldohexose. According to Gailliot *et.*